SEPTEMBER 7.

Dr. R. S. KENDERDINE, in the chair.

Fifteen persons present.

On large Sphene from Canada.—Dr. A. E. Foote recorded the occurrence of crystals of sphene of unusual size in the county of Renfrew, Canada, near the upper part of the navigable portion of the Ottawa River. The largest crystal collected weighed 23½ pounds or more than twenty times as much as the largest heretofore found.

SEPTEMBER 14.

The President, Dr. RUSCHENBERGER, in the chair.

Twenty-eight persons present.

The death of Prof. S. S. Haldeman, a member, was announced.

On the Timber Line of High Mountains.—Mr. MEEHAN remarked that on the tops of most high mountains we find a total absence of ligneous plants. The highest alpine vegetation consists for the most part of acaulescent perennials. Lower down we may find some woody species, and often we come to dwarfed forms of trees of species, which, still lower down, form forests of considerable height, and which as timber trees make what is known to mountain travelers as the "Timber Line." Thus in the mountains of Colorado, the forests commence at about 7000 feet above the sea level, and continue up to about 11,000 feet, where they suddenly cease, and form at that elevation what is there known as the "Timber Line." On Gray's Peak he found *Pinus aristata*, *Pinus flexilis*, *Abies concolor*, and *Abies Engelmannii*, with some willows forming the timber line. The Coniferous trees were probably 30 or 40 feet high, and it was interesting to note that this tall timber as suddenly ceased, as if a wood had been cut half away by a woodman's axe. But at once commencing where the tall timber ceased, the same species exist as dwarf stunted shrubs seldom exceeding 3 or 4 feet in height, and often but a foot, though trailing widely over the ground. In this stunted condition the species would often extend some fifteen hundred feet higher up, or half way from the recognized timber line to the top of the mountain. Other observers have noted that the average of 11,000 feet marks the entire timber line of the Rocky mountain range.

So far as he knew this peculiar timber line has been referred wholly to climatic conditions, of which temperature and moisture

have been regarded as the chief elements in producing the results. That admirable botanist and energetic collector, Dr. C. C. Parry, in a paper on the Rocky mountain alpine region, published in the "Proceedings of the American Association for the Advancement of Science" for 1869, p. 249, remarks that the most satisfactory explanation is that the so-called timber line marks the extreme point of *minimum* temperature below which no exposed phenogamous plant can exist. All that survives above this point does so by submitting to a winter burial of snow, beneath which protecting cover it is enabled to maintain its torpid existence.

The great objection which this purely meteorological view presented to Mr. Meehan's mind was that the dwarfed and gnarled coniferae extending so many hundred feet up the mountain sides, never produced seed, and we are reduced to the alternative of believing either that the seeds have been carried up the mountain sides in enormous quantities and to enormous distances from the fruitive trees below by winds, or else that there were seed bearing progenitors of these scrubby pines, beneath the tall protecting branches of which they had their earliest stages of growth. He was satisfied from subsequent observations in the mountains of North Carolina, and in the White Mountains of New Hampshire, that this last view is the correct one,—that large timber trees at no very remote period extended much further up the mountain sides than they do now, and that they have since disappeared for reasons presently to be stated, leaving only the younger trees to struggle on as best they may.

Roan Mountain in North Carolina is about 6300 feet above the level of the sea. Timber extends to its summit on some parts of it, while in other parts it is destitute of timber for many hundreds of feet down its sides. The species on the summit is *Abies Frazeri*, and *Abies nigra*. Oak and other trees come occasionally to near the top and at about 6000 feet he measured a black oak—*Quercus tinctoria*, that was 5 feet in circumference at 3 feet from the ground, and was perhaps 40 feet high. The places destitute of trees were the steep declivities,—while those on which the trees were growing were of a more level character. Further down the mountain sides the steep inclines would be clothed with forest growth, as well as those of a more gradual ascent. It is of the summit only that the differences in inclination, presented different forest aspects. But in the spaces clear of "Balsam" as the *Abies Frazeri* is popularly known, an occasional one of good size would be seen. In the close Balsam woods, both on the summit and lower down the mountain sides, crops of young plants would be found under the mature trees, but, what was very remarkable, there had evidently been no young trees started till the parents were near maturity. A large area with trees 30 or 40 feet high would have an undergrowth of young ones a foot or so high, while other areas of younger trees, would have innumerable small seedlings growing among the damp moss beneath them, and it

was further interesting to note that in most cases the crops of young plants in each area were about the same age in each case, as if the seeds in the several locations had all started to grow together in some one particular year, and probably at no other time. On the naked places, where few or no trees were now found, the surface would be closely covered by a matted growth of a grass almost peculiar to that region, *Danthonia compressa*, but a close examination of the surface showed occasional tracts of deep vegetable mould which had been formed by ages of decaying *Hypnum* or Sphagnum moss, and the evident remains of roots, just as we now find under the Balsam trees, and there is no doubt from these facts that these steep upper declivities were once clothed with trees and mosses, to which the grass previously named succeeded.

With these facts in mind he examined the arboreal features of the White Mountains in New Hampshire. On Mount Washington, which is a little over 6000 feet, the timber runs up to about 4000 feet; while Mount Webster, a mountain forming the southern peak of the same chain, and about 4000 feet high, has little timber above 3000 feet. Clearly, climatic reasons will not account for these peculiarities. On Mount Washington there is much of the same character as distinguishes the forests of the Rocky Mountains. As already noted the timber line becomes marked at about 4000 feet. For at least another thousand feet we meet with scrubby bushes of *Abies Balsamea*, *Abies nigra*, and *Abies alba*, with some *Betula papyracea*. Beyond this, and almost to the summit, an occasional specimen of one or another of the coniferæ may be seen. As noted in regard to the Colorado scrubby growth, none of these had ever produced seed; nor was it at all probable, from a careful survey of the locations, that many of the areas could have been seeded by the winds, however strong, bringing the seeds up these mountain heights. Moreover, there were many cases where there were intermediate areas clear of all scrubby spruce plants, and where seeds could be brought by winds in these modern times much easier than to the heights above. Besides this, it was evident that many of these dwarfed specimens were of immense age. Some that he examined were certainly fifty years old, though the stems at the ground were no thicker than his wrist, and, trailing on the ground, occupied but 16 or 20 square feet of space. There seemed to be but little doubt that at some time in the past Mount Washington had forests of coniferæ at much higher elevations than at present, if not perhaps clean up to the summit; that these scrubby plants now there were seedlings that had sprung up under the elder ones, and that in time the older ones were destroyed, leaving the small ones beneath alone to their fate.

An examination of different parts of Mount Washington shows not only that this is the true explanation of the absence of good timber beyond what is known as the timber line, but that the same law is in progress to day as in centuries past. Illustrations

of this are numerous. There is now a railroad running straight up the mountain side from the base to the summit. Near the timber line, a cut had to be made through an area covered by mature Balsam Firs. This cut was about 8 or 10 feet deep. Under the trees moss and dead roots and old fir leaves had made an earthy strata of a foot, or in places, more in depth. The moss was still green from the rains, melting snows, and fogs of this elevated region, and sustaining the various kinds of low vegetation common to these alpine heights. Young firs were springing up in great abundance. But all the larger trees were dead, though here and there might be seen a branch with a few lingering green leaves. This mass of dead, standing timber occupied several acres. The reason for their death was evident. The railroad cut showed that the forest stood on a mass of large but loose gneiss rocks, through which the waters from the two thousand feet of loose rock above rushed as soon as the railroad cut was made, carrying with it all the earthy matter on which the larger trees subsisted, but leaving the tough turfy matter at the surface, on which smaller trees of the same sort may live for many years, though the larger ones cannot longer exist. With the death of the larger trees there is, of course, an increase of light, and then the *Hierochlœ*, with other grasses and sedges, speedily take possession, holding together the loose soil, and even permitting in many cases an increase of the earthy layer, by holding much of the disintegrated rock which may be washed or blown on from above. Carefully examining patches of scrubby spruces above the timber line, it is not uncommon to find dark patches of vegetable mould evidently the remains of large trees that have been growing where now only the masses of small scrubby plants exist. In some places a sharp stick may be pushed down among the scrubby firs and spruces, and the earth found to be but a foot or so deep over the loose rock below, from which the earth has been wholly washed away. Again, there are some places often nearly an acre in extent where the scrubby firs are still standing, dead, from the earth having been washed away from below upwards, not leaving enough for even the moderate demands of these little bushes.

In view of the facts detailed we may conclude that at the elevation of these mountain chains, the lowland vegetation was carried up at the same time. The summits, covered by luxuriant forests would present a cooler surface to the moist clouds, and there would be less condensation than on bare sun-warmed rocks, and deep snows would be less frequent, and not sufficient to interfere much with arboreal growth. But the rain would of necessity carry down the earth and disintegrated rock to lower levels; and the melting snows, such as there were, would make this downward progress of the soil continuous. In some mountains where the rock was easily broken by frost, as in Colorado and the White Mountains, it would be very difficult for the soil to hold its own against these forces of gravitation; but on more solid rock the mass of tree

roots protecting the rock, and retaining the earthy matter would longer hold its own. In the former case with the gradual washing away of the earth the larger trees will have to find a lower level; the summit condensing more moisture, and having a cooler atmosphere, would form heavier masses of longer enduring snow, and thus keep down from tall growth the younger trees left as the older and larger ones retired. They would have to be low bushes by the absence of earth for vigorous growth, and remain trailing bushes, through the superincumbent and long continued mass of snow.

We thus see that though a long continued mass of snow has much to do in marking a timber line, that line is precedent to the snowy mass. The primary cause is the gravitation of disintegrated rock—the movement of the hill top towards the sea. From the moment the mountain reaches its highest point it commences its downward march. The entire reduction of the highest to a level with the plain is but a question of time. The frost and rain and melting snow will do it all, and this reduction, bringing down not only the earth, but cold-loving plants to warmer levels, must continually change the aspects of vegetation, as well as perpetually vary the timber line.

In low hills as well as in high mountains the forces of gravitation are also at work. But the sides are seldom so steep as in the loftier hills,—the rains do not gather with such force nor are the melting snows of near the same duration. There are sudden washes, but not the continuous roll of the earth to the bottom. In time they may exhibit the same phenomena of the disappearance of species from their summits as their loftier brethren; but the centuries here will gather much more slowly to produce a similar effect.

In conclusion he would say briefly that the "timber line" of high mountain tops results from the washing down of the earth from the higher elevations.

Mr. REDFIELD remarked that there could be no doubt that influences other than climatic (such for instance as the washing away of soil, mentioned by Mr. Meehan) do often modify and change the timber-line upon mountains. But he was unable to accept Mr. Meehan's views as to the insignificant part played by climatic causes, and still held them to be the prevailing factor in the problem. Dr. Parry's explanation by the weight and depth of winter snows might not always be the correct one, but snow and ice must be very important agents, and Mr. R. thought that in considering climate, we should have regard not merely to the present period, but to past great secular periods. He then referred to the glacial age, when not only the White Mountains, but all New England was capped with a vast ice-sheet, which under secular changes gradually retreated, leaving only the mountain tops covered. The slow retreat of the glacial covering was followed

by the advance of fitting arboreal vegetation, until a point was reached when the present climatic conditions were such as to limit any higher advance of the trees.

SEPTEMBER 21.

The President, Dr. RUSCHENBERGER, in the chair.

Twenty-eight persons present.

Bone Caves of Pennsylvania.—Prof. LEIDY remarked that in the early part of August, in company with Dr. T. C. Porter of Easton, he had visited Hartman's Cave, in the vicinity of Stroudsburg, Pa. They had been invited by Mr. T. Dunkin Paret, of that place, who had recently undertaken the exploration of the cave, and had obtained from it an interesting and important collection of animal remains, which had been submitted to Prof. Leidy's examination.

The cave is situated about five miles from Delaware Water Gap in a ridge which separates Cherry Valley from the valleys of the Pocono and McMichael's Creeks. The ridge is an anticlinal fold of the Helderberg or Upper Silurian limestone, and the cave, occupies the axis of the fold and opens in the face of a cliff formed by a cross section of the ridge. An accumulation of debris forms a slope at the base of the cliff, and above the debris and just below the arching roof of the cave, a low passage way has long been known into which adventurous boys would creep.

Mr. Paret commenced the exploration by having a passage dug through the debris to the entrance of the cave, and then extended the trench within the latter for upwards of a hundred feet, and to a depth sufficient to walk erect. At one place within the cave the digging was carried to the rock floor. It would thus appear that the cave is occupied by a bed of clay about 10 feet in depth. On this is a thin layer of stalagmite and on this again about a foot of black friable earth mingled with animal and vegetal remains.

No remains have been found imbedded in the clay nor on the rocky floor in the pit dug through the latter.

Prof. Leidy supposed that during the glacial period, a stream of water, from melting snow and ice at a higher level, had made a passage way through the fissured limestone of the anticlinal axis and had left in it the abundant clay deposit. When the cave ceased to be a water course the layer of stalagmite was formed and subsequently the more friable earth accumulated from materials, such as dust and leaves, blown in and mingled with the remains of animals, occupants of the cave, and of their food. The recess of the cave above the clay floor appears to have been too small to be inhabited by the larger carnivorous animals or man, and therefore no large entire bones of these have been found in the ossiferous stratum.